

LEADER TEST INSTRUMENTS

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MODEL LTC-906

TRANSISTOR CHECKER

INSTRUCTION MANUAL



LEADER ELECTRONICS CORP.

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LEADER ELECTRONICS CORPORATION

LTC-906 TRANSISTOR CHECKER OPERATING INSTRUCTIONS

1. General

1.1 Transistor checker LTC-906

The LTC-906 is a transistor tester which is capable of determining good/bad of transistor, FET, UJT, diode, etc. and also performing automatic determination of the proper leads in-circuit and out-of-circuit. This tester is also capable of DC parameter measuring transistor and diode out-of-circuit.

1.2 Features

- a. Auto-measurement which automatically scans electrode. Electrode change-over by switch is not required.
- b. Automatic determination Good/Bad of specimen.
- c. Automatic identification of the lead configuration.
- d. Both transistor and diode can be measured.
- e. Audible indication of test result. This permits the operator to pay his attention to the end of probe.
- f. Drive power can be selected either at LOW/HIGH.
- g. In measuring V_{BE} of transistor and V_D of diode, Silicon type and Germanium type can be distinguished.
- h. Leak current of transistor and diode can be measured.
- i. h_{FE} of transistor can be measured.
- j. 2 way power supply system of internal battery/external power supply.

2. Specifications

2.1 Auto-test

AUTO-test can be accomplished both in-circuit and out-of-circuit

operation.

- a. Semiconductors which can be tested

Bipolar transistor, J-FET, MOS-FET, UJT, SCR, Diode

- b. Item of test

GOOD/BAD

Polarity (PNP/NPN, P CHANNEL/N CHANNEL)

Base/Collector of transistor

Gate/Drain of FET

Cathode/Anode of diode

- c. Measurement mode

Transistor and diode

- d. Measurement voltage

Approx. $\pm 2V$, duty ratio about 10%

- e. Measurement current

LOW DRIVE ... Maximum 4.5mA, average 0.45mA

HIGH DRIVE ... Maximum 60mA, average 6mA.

- f. Measurement speed 1 - 10 times/second

- g. Display

Light emitting diodes and sound by buzzer

2.2 DC parameter measurement

Out-of-circuit operation alone. V_{BE} , I_{CEO} and h_{FE} of bipolar transistor and V_B and LEAK of diode are indicated by meter.

- a. Measurement mode

Transistor and diode

- b. Polarity to be measured

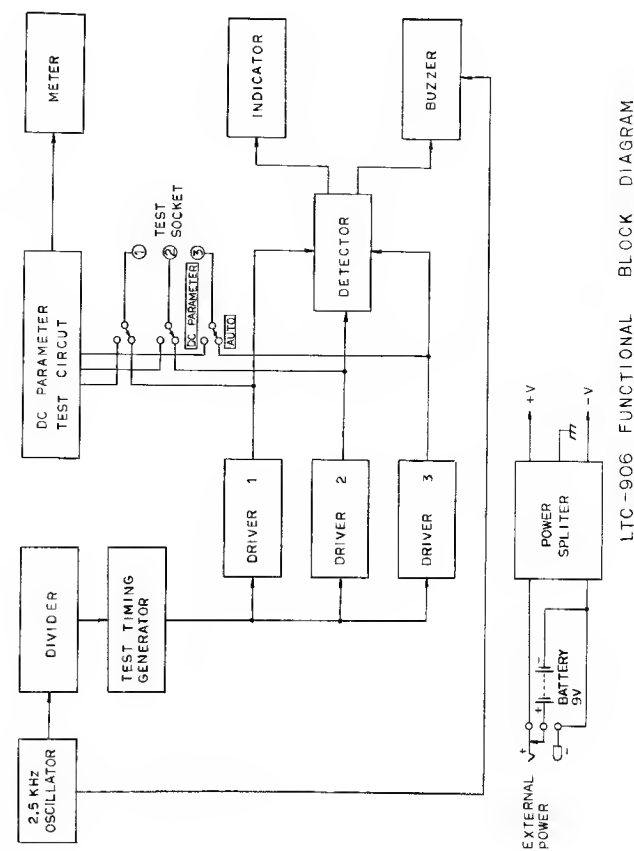
PNP and NPN transistors and forward and backward diodes

- c. Measuring range

V_D , V_{BE} 0-3VDC 1 range, Accuracy $\pm 6\%$ of FS

- LEAK, I_{CEO} 0–100 μ A, 0–1,000 μ A, 0–10,000 μ A
3 ranges Accuracy $\pm 6\%$ of FS
- h_{FE} 0–100, 0–1,000, 0–10,000 3 ranges
Accuracy $\pm 20\%$
- d. Measuring current
- V_D, V_{BE} Maximum 2mA
- h_{FE} Base current $\pm 1\mu$ A
Collector current Maximum 30mA
- e. Measuring voltage Maximum $\pm 5V$
- 2.3 Power supply
- Internal battery Standard 9-volt transistor radio battery
(EVEREADY 216,
MALLORY MN1604)
- External DC 8–10V, 25mA
- 2.4 Dimensions and weight
- 152(H) \times 110(W) \times 60(D) mm (excluding handle)
About 0.4 kg.
- 2.5 Accessory
- 3-lead test cable 1 ea.
- 2.6 Options
- AC adapter LPS-169A DC9V, 25mA
- In-circuit probe LP-11

3. Distribution diagram



SCHEMATIC	Model LTC-906	0-1041 (1/2)
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4. Description of panel

4.1 General

The front panel of LTC-906 is divided into three functional sections, upper, middle and lower as shown in Fig. 4.1.

In the middle portion of the panel, those functions which are related to all types of test are concentrated. ① - ④. In the lower portion painted in brown, functions which are related to auto-test of good or bad of transistor and leads identification are installed ⑤- ⑩.

In the upper portion of the panel painted in green, functions which are related to DC parameter test of bipolar transistor and diode are concentratedly installed. ⑪ - ⑮.

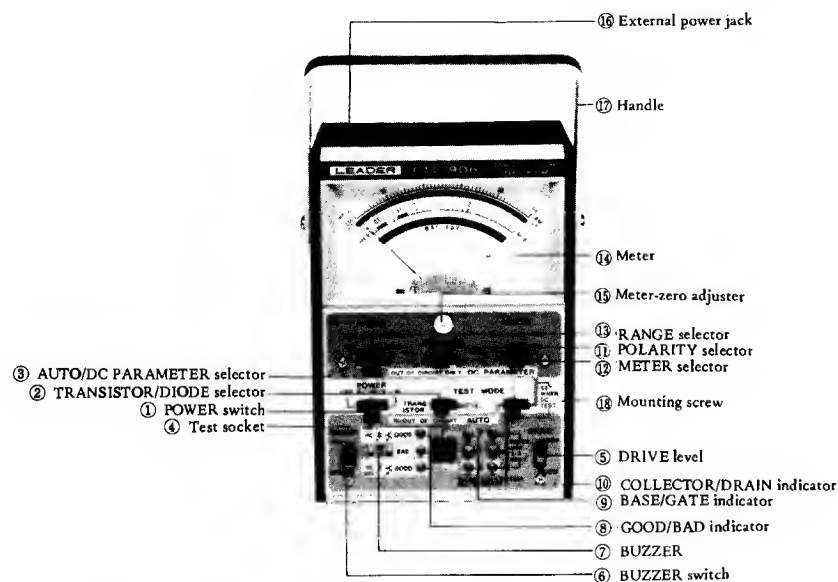


Fig. 4.1 Front Panel of LTC-906

4.2 Description of each functional section

A. Middle section

① POWER switch

This is a slide switch with 3 positions for turning power on or off. When the switch is slid to the left, power is turned off, at the middle position battery can be checked, and at the right, power is turned on.

Under battery check condition, the meter indicates whether the voltage of a battery in operative condition or that of external power supply is within a proper range or not.

② TRANSISTOR/DIODE selector

This is a slide switch with 2 positions for setting the tester's test mode either to transistor or diode.

Test mode is set at transistor when the knob is slid to the left and at diode when at the right.

③ AUTO/DC PARAMETER selector

This is a slide switch with 2 positions for setting the tester's test mode either to Auto-test for judging good/bad of transistor and diode and identifying the proper leads, or DC PARAMETER test for measuring forward voltage, leak current and current amplification ratio. Test mode is set at Auto-test when the knob is slid to the left and at DC parameter test when at the right.

④ Test socket

This is a socket into which a transistor or diode to be tested is inserted. In the case of in-circuit test, a plug of test lead is connected to this socket.

The socket has 3 contacts divided into upper, middle and lower, and they are numbered from upper in sequence as 1, 2 and 3 for identification. In addition to numbers, these are also identified by color for matching with test leads as follows:

Upper - 1 - Blue
Middle - 2 - Green
Lower - 3 - Yellow

In case a diode is tested, the middle contact is not used, and 1-blue and 3-yellow contacts are used.

B. Lower section

The following function units from reference numeral 5 to 10 become effective in the case of AUTO-test mode, and they are irrelevant to DC PARAMETER test:

⑤ DRIVE power

This is a slide switch with 2 positions for select-test current, HIGH or LOW, in the case of AUTO-test.

The power of test current is set at LOW when the knob is slide down, and on the contrary, it is set at HIGH when slid upward.

⑥ BUZZER switch

This is a slide switch with 2 positions for turning buzzer function on or off. The buzzer is turned on as the knob is slid upward, and on the contrary it is turned off when slid downward.

⑦ Buzzer

This buzzer (small speaker) generates sounds when a transistor or diode under test is in good condition in the case of AUTO-test. When this function is not required, it can be turned off.

⑧ GOOD/BAD indicator

This indicator consists of 3 LEDs which indicate good/bad of a transistor or diode under test, PNP or NPN of transistor and the polarity of diode in the case of AUTO-test.

⑨ BASE/GATE indicator

This indicator consists of 3 LEDs which indicate which one of the 3 contacts of the test socket a control electrode such as the base of a bipolar transistor, and the gate of a field-effect transistor is

connected to in the case of AUTO-test of transistor. Only when the transistor under test is in good condition, one of those LEDs corresponding to the base is lighted.

⑩ COLLECOT/DRAIN indicator

Like the base/gate indicator, this consists of 3 LED which indicate collector of bipolar transistor or drain of field-effect transistor in the case of AUTO-test of transistor. In case of transistor under test is good in quality, one or two LEDs corresponding to the contacts of the socket are lighted.

C. Upper section

The following function units from reference numeral ⑪ to

⑮ become effective only in the case of DC PARAMETER test of bipolar transistor and diode, and they are irrelevant to AUTO-test:

⑪ POLARITY selector

This is a slide switch with 2 positions for setting LTC-906 to conform with the polarity of a transistor or diode when it is DC PARAMETER test.

In case a PNP transistor or a diode of which cathode is at contact 1 side of the socket is tested, the knob is slid to the left, and in case an NPN transistor or a diode of which cathode is at contact 3 side is tested, the knob is slid to the right.

⑫ METER selector

This is a slide switch with 3 positions for selecting a proper meter display at the time of DC PARAMETER test. At the time of transistor test mode, the meter indicates V_{BE} , the voltage in forward direction between base and emitter when the knob is slid to the right, I_{CEO} , collector leak current with base open when it is set at medium position and h_{FE} , DC current amplification ratio when it is slid to the left.

At the time of diode test mode, the meter indicates V_D , the

voltage in forward direction, when the knob is slid to the right, and indicates leak current in the reverse direction, LEAK when it is set at medium position. In the case of diode test, the left position of this meter selector has no function.

⑬ RANGE selector

This is a slide switch with 3 contact points for selecting one of three meter scale magnification ratios, $\times 1$, $\times 10$ or $\times 100$, to indicate h_{FE} and I_{CEO} of transistor and LEAK of diode at the time of DC PARAMETER test.

Its ratio is set at $\times 1$ when the knob is slid to the left, and at $\times 10$ when it is set at medium position and at $\times 100$ when the knob is slid to the right. The magnification ratio for V_{BE} and V_D is $\times 1$ regardless the range selector.

⑭ Meter

This is a DC ammeter for indicating h_{FE} , I_{CEO} and V_{BE} of a transistor and LEAK and V_D of a diode in the case of DC PARAMETER test. When the power switch is at the battery check position, the meter indicates whether the voltage of battery in operative condition or that of external power supply is within proper range or not regardless the position of other switches.

⑮ Meter-zero adjuster

This mechanically adjusts the meter needle to zero. When the power switch is off, adjust the meter needle to zero by rotating the screw.

D. Other parts

⑯ External power jack

This is an external power jack to which external DC power supply of DC9V can be connected. AC adapter, LPS-169A is fitted to this jack.

⑰ Handle

⑱ Mounting screw

The battery compartment can be opened by loosening 2 mounting screws located at left and right when a battery is replaced.

5. Operation of LTC-906

5.1 General

5.1.1 For safety

In making a test of an electronic apparatus, it involves a risk in many cases. There is a possibility that a high voltage is being generated at unexpected parts in the equipment which is out of order. Please pay attention to the following points:

- (1) The power switch of an apparatus to be tested should be turned off and a power supply cord should be disconnected from AC outlet when a test lead is connected or disconnected from the apparatus. If this is impractical do not touch metal portions of such an apparatus and work should be performed on the floor of good insulation to reduce the influence of electric shock.
- (2) Electric charge of filter capacitors should be discharged before connecting a test cord to the apparatus. Such a condenser may be fully charged up to a dangerous degree.
- (3) It is necessary to keep a test instrument in good condition. A test lead which is partly broken or its covering is partially missing may accidentally come to contact with a dangerous potential.
- (4) Upon completion of test, the test leads should be immediately disconnected from an apparatus.

5.1.2 Replacement of battery

The LTC-906 can be operated on one unit of a standard 9 volt transistor radio battery. Prior to operating the checker, a new battery must be installed as it has no battery installed. A battery

can be mounted by the following procedures. Replacement of battery after 2nd time can be accomplished in the same manner.

- (1) Be sure to turn the power switch off. This is important. If this is neglected, the LTC-906 may be damaged by an unexpected accident such as inverted connection or shortcircuit of a battery.
- (2) Loosen the 2 screws at the left and right of battery case with a screw driver and remove the case.
- (3) If an old battery is mounted, remove it from a battery holder located at the bottom of case, and then disconnect from a battery snap connected to the main unit of checker.
- (4) Connect a new battery with proper polarity set to the battery snap and set the battery in the battery holder at the bottom of case.
- (5) Place the case in the checker with care exercised not apply undue force to printed circuit board and lead wire of battery snap and fix it with 2 screws.

5.1.3 Battery check

The voltage of a battery required to have LTC-906 perform correct operation is 7V or larger. If the battery voltage decreases, the proper operation of LTC-906 will be hampered.

When the power switch is set at battery check position, the meter indicates the range of battery voltage under an optional operation condition of LTC-906 (or the voltage of an external DC power source when used.).

The battery is in good condition if the meter needle is within the range of GOOD of the battery scale, and it must be replaced with a new one if the needle indicates the range of REPLACE.

The terminal voltage of a battery becomes smaller in inverse proportion to its current due to voltage decrease of internal

resistance even if its internal electromotive force is the same. Consequently, the battery voltage of LTC-906 when it is in such operational condition in which a large battery current is being consumed becomes lower than that of such a case in which a small current is being consumed.

A current being consumed by LTC-906 under no load;

DC PARAMETER test	About 2 mA at 9V
AUTO-test	About 15 mA at 9V.

When a load is connected, its power consumption is further increased, and it may exceed 30mA depend on the type of load and way of connection.

As aforementioned, the battery current of LTC-906 varies considerably depend on its operative condition, and its operation time is fairly long as much as several tens hours if its current is small, and on the contrary it becomes shorter less than one hour if its current is large.

In order to use the battery economically and lengthen its life, measurement should be carried out quickly as short as possible and the power switch should be turned off upon completion of measurement.

5.1.4 External DC power supply

The LTC-906 can be operated by external DC power supply which is 7 to 10V and more than 25mA connected to the external power source jack. The outer circumference of the jack is positive and its internal pin is negative in polarity. The LTC-906 may be damaged if an external power source is inadvertently connected inverse position.

As an external power source suitable for the LTC-906, AC adapter type LPS-169A (option) is available.

LPS-169A	Input AC 50/60Hz 100-120V 4.5VA
	Output DC 9A 25mA

In case the checker is used for a long time, it will be economical to utilize AC adapter than battery operation which require battery replacement.

5.1.5 Other precautions

- (1) A used-up battery may give bad influence to the LTC-906 by its leaked battery liquid, therefore, such a battery should be immediately removed from the checker. By the same reason, a battery should be kept removed when the checker is not used for a long time.
- (2) It is dangerous to cause a battery to short or to throw it into fire.
- (3) When the LTC-906 is carried, its power switch should be kept off regardless the presence or absence of a battery. With the power switch set at off position, the moving coil of the meter is made short, and by its brake action, adverse influence of mechanical shock while in transit to the meter will be reduced.
- (4) The LTC-906 should be carefully handled not to give strong mechanical shock.
- (5) Please do not place the checker near a fire or leave it inside a car under the blazing sun. Plastic portion may be deformed by heat.
- (6) Do not use solvent such as alcohol, thinner, benzine, etc. for cleaning the checker. These solvents may dissolve the paint or plastics of the checker.

The checker should be cleaned with a slightly wet cloth.

5.2 Auto-test

The LTC-906 is capable of making in-circuit and out-of-circuit test of bipolar transistor, field-effect transistor (FET), SCR, UJT, diode, etc.

For AUTO-test, there are 2 modes of transistor and diode which

can be selected by the TRANSISTOR/DIODE selector.

The AUTO-test unit automatically scans test signal being impressed to the electrode of a semiconductor to be measured and determines whether it is good or bad, and identifies the electrode, if it is good, and causes LEDs to display its results.

Together with LED display, the result of test is notified by the sound of a buzzer (small speaker) when a semiconductor is good in quality. Consequently, the operator can concentrate his attention to perform testing without looking at the display panel for confirming the result of each test, and it is possible to perform efficient in-circuit test.

When this buzzer sound is not required, this function is turned off by the buzzer switch.

For making in-circuit test, connect the plug of the attached test lead to the test socket with its lead wires adjusted to corresponding colors displayed on the panel, and then connect its clip to a transistor or diode to be measured.

When an in-circuit probe Model LP-11, an option, is used being connected to the end of the test lead, semiconductors installed on the printed circuit board can be easily measured as the probe's tip can be freely moved depend on the arrangement of legs of such semiconductors.

The attached test lead should be used when a transistor or diode cannot be directly inserted into the test socket for out-of-circuit test.

Caution for in-circuit test

- (1) Prior to connecting the test clip or probe to an circuit under test, be sure to turn the power switch of the circuit off and cause electric charge accumulated in the capacitors to completely discharge through a resistor of several tens

ohms.

The LTC-906 may be damaged if a voltage of more than $\pm 5V$ is externally applied to it.

- (2) Upon completion of test, the test clip of LTC-906 should be disconnected from the circuit before its power switch is turned on.

5.2.1 Transistor auto-test

- (1) Set the AUTO/DC PARAMETER select at AUTO.
- (2) Set the TRANSISTOR/DIODE selector at TRANSISTOR.
- (3) Turn the power switch on.
- (4) Turn the BUZZER switch on when audible GOOD signal is desired. Keep it off if not so desired.
- (5) Set the drive level at LOW.
- (6) Insert a transistor directly into the test socket (out-of-circuit). Or, connect 3 clips of test lead coming from the test socket or 3 tips of test probe to the 3 legs of a transistor to be measured. Connection of electrode must continue more than 2 seconds.
- (7) The GOOD/BAD indicator should display GOOD signal if the transistor is good. If a GOOD LED located at upper flashes, the transistor is of PNP or P channel, and on the contrary the lower GOOD LED flashes, it is on NPN or N channel. At the same time, LEDs of the base/gate indicator and collector/drain indicator flash and the electrode of the transistor corresponding to test leads can be identified. If the buzzer switch is on, intermittent sounds are generated.
- (8) If the BAD display LED is kept lighted (the buzzer does not generate sound), the transistor is bad or drive level is inadequate due to a heavy load in the circuit around the transistor.

- (9) Change-over the drive level to HIGH and repeat test from (6) to (8) in the case of the in-circuit test.
- (10) If it is judged as BAD again, the transistor is bad or drive level is still inadequate.
- (11) In the case of in-circuit test, disconnect the transistor which has been judged as BAD by the step (10) from the circuit, and test it again by out-of-circuit AUTO-test at LOW and HIGH drive level.

If the transistor is judged as BAD at both LOW and HIGH drive level, it should be short-circuit, broken or deteriorated. If transistor is of bipolar type, perform DC PARAMETER test described in Par. 5.3.1 to make sure it is really bad or not.

- (12) To test another transistor, return to Step (5).
- (13) Identification of leads

a. Bipolar transistor/FET

When the base bipolar transistor and field-effect transistor of MOS type or junction type are in good condition, one of the three LED of the base/gate indicator corresponding to contacts 1 to 3 of the test socket flashes.

Similarly, when the collector of bipolar transistor or the drain of FET is in good condition, a corresponding LED of the collector/drain indicator flashes. In this case, the collector/drain indicator displays one electrode excluding base, or 2 electrodes at the same time. The reason why it displays 2 electrodes simultaneously is that the collector and emitter of a bipolar transistor and the drain and source of an FET have amplification function even if

they are exchanged. Especially, the drain and source of junction type FET have a perfect symmetry in many cases.

In the case of out-of-circuit, the collector/drain indicator frequently displays 2 LEDs at the same time, and in the case of in-circuit test, it displays 1 or 2 depend on the condition of circuits.

In order to identify the emitter and collector, cannot be identified by AUTO-test, of a bipolar transistor, h_{FE} of the transistor is measured by DC PARAMETER test. From a generally known fact that h_{FE} of such a transistor becomes lower than that of normal operation when its collector is caused to operate as emitter, the collector and emitter of a bipolar transistor can be distinguished.

b. SCR or thyristor

In the case of SCR or thyristor test, both GOOD indicators of P type and N type flashes alternately when it is in good condition.

The base/collector indicator flashes simultaneously at 2 points and this corresponds to anode or gate. Also the collector/drain indicator flashes at 1 point, and this corresponds to cathode.

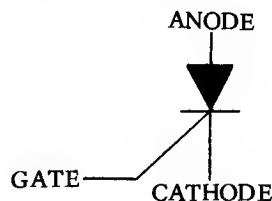
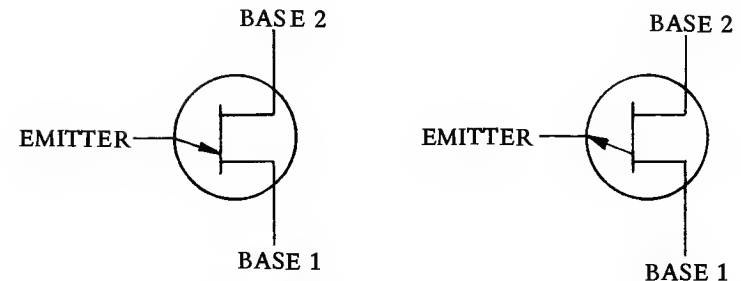


Fig. 5.2.1-1 SCR

c. Unijunction transistor

In the case of a good unijunction transistor (UJT), the GOOD/BAD indicator causes its LED at NPN transistor side (lower) to flash when the UJT is of N base (or P emitter) type, and causes its LED at PNP transistor side (upper) to flash when it is of P base (or N emitter) type.

The base/gate indicator flashes at one point and displays the emitter of UJT. The collector/drain indicator flashes at one point which indicates Base 2, or flashes at 2 points which indicate Base 1 and Base 2.



N BASE or P EMITTER UJT

P BASE or N EMITTER UJT

Fig. 5.2.1-2

Caution Programmable UJT cannot be AUTO-tested.

d. Dual bipolar transistor/dual FET

The electrodes of dual bipolar transistor and dual FET can be identified in the same manner as that of single type if it is known that how those 6 or 5 legs (emitter or drain is common) can be divided into two sections.

(14) Drive power

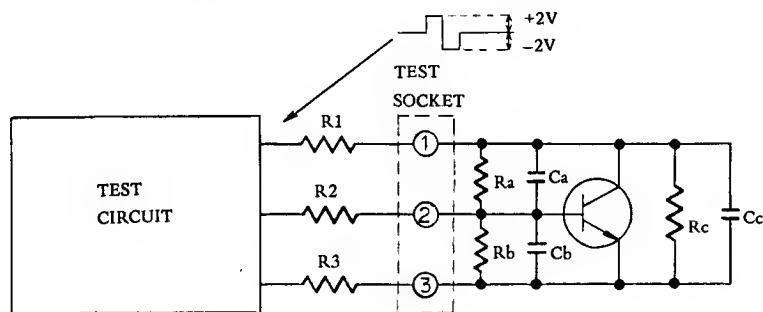


Fig. 5.2.1-3 Basic circuit of transistor AUTO-test

		DRIVE LEVEL	
		LOW	HIGH
SOUSE RESISTANCE	R ₁ R ₂ R ₃	470 Ω	33 Ω
	R _a R _b	Over 1k Ω	Over 220 Ω
LOADE	C _a C _b C _c	Below 0.1 μ F	Below 2.2 μ F

Table 5.2.1-1 Limit value of load (when independently exist)

As shown in Fig. 5.2.1-3, in the basic circuit for transistor AUTO-test, a test pulse voltage of about $\pm 2V$ is connected to the test socket through a series of current limit resistors R_1 , R_2 and R_3 . The value of these resistors is 470Ω at LOW DRIVE and 33Ω at HIGH DRIVE, and measuring pulse current is $4.5mA$ maximum at LOW DRIVE and $60mA$ maximum at HIGH DRIVE.

Since the duty ratio of measuring pulse is less than 10%, an average measuring current is less than $0.45mA$ at LOW DRIVE and less than $6mA$ at HIGH DRIVE.

Since measurement is performed by such a small average current like this, there is hardly such a possibility that transistors of small signal may be damaged by the measuring current. However, such small signal transistors of which allowable current is very small should be tested at LOW DRIVE alone.

There is such a case that some FET and UJT are not judged as GOOD due to on resistor of high output when tested at HIGH DRIVE. Also, some SCRs are not judged as GOOD due to the shortage of gate current when tested at LOW DRIVE.

In the case of in-circuit test, generally there exist resistor R_a - R_c and capacitor C_a - C_c between electrodes of a transistor as shwon in Fig. 5.2.2-3. The values of these resistor and capacitor which do not hamper the judgement of AUTO-test must be less than those limit values shown in Table 5.2.1-1 when they exist independently. In this case, its power supply voltage must be over 8V;

In case h_{FE} of a transistor is less than 100, power voltage is less than 8V and load resistors or capacitors exist

simultaneously more than 2, the value of allowable load resistance will be larger than those shown in the table and the value of capacitor will be smaller.

5.2.2 Diode AUTO test

- (1) Set the AUTO/DC PARAMETER selector at AUTO.
- (2) Set the TRANSISTOR/DIODE selector at DIODE.
- (3) Turn the power switch on.
- (4) Turn the BUZZER switch on when audible GOOD signal is desired. Keep it off if not desired.
- (5) Set the drive level at LOW.
- (6) Connect the 2 electrodes of a diode to directly 1 or blue and 3 or yellow of contacts of the test socket, or connect them by means of a test lead or probe in the same manner. Connection of electrodes must continue longer than 1 second.
- (7) One of the 3 LEDs of the GOOD/BAD indicator which coincides with the direction of the connected diode should flash if the diode is good. At the same time, the buzzer generates short intermittent sounds indicating good condition if it is on.
- (8) If the BAD indicator is kept lighted, the diode is bad or DRIVE power is inadequate.
- (9) Change-over the DRIVE power to HIGH and repeat test.
- (10) In the case of in-circuit test, drive level may become inadequate even if it is set at HIGH if a load is heavy. In such a case, disconnect the diode from the circuit, and test it under out-of-circuit at LOW or HIGH level.
- (11) If the diode is judged as BAD at both LOW/HIGH under out-of-circuit test, it should be short-circuit, open or deteriorated, or it may of special type which cannot be

identified by this instrument.

The reason for BAD may be clarified if it is tested by DC PARAMETER measurement described in Par. 5.3.2 for confirmation.

- (12) To test another diode, return to Step (5).

(13) DRIVE power

The basic circuit of diode AUTO-test is substantially the same as those shown in Fig. 5.2.1-3 of transistor, and contacts 1 and 3 of the test socket alone are used for diode. The values of voltage and current of measuring pulse are the same.

The values of allowable parallel load resistance and capacitor between test socket contact 1 and 3 are as follows when each independently exists:

Over	1 k Ω
Below	0.1 μ F when drive level is LOW
Over	220 Ω
Below	2.2 μ F when drive level is HIGH

However, power voltage must be over 8V.

In case the voltage of power source is lower than 8V, or resistor and capacitor exist simultaneously in parallel with the diode, the value of allowable resistor must be made larger and the value of capacitor must be made smaller.

Caution

In case the value of parallel load capacity between contact 1 and 3 of the test socket is larger than an allowable value, the two GOOD indicator LEDs at the upper and lower may alternately flash even if a diode is not placed between test terminals.

(14) Diodes which cannot be AUTO-tested.

Meter protection diode

Temperature compensation diode

Light emitting diode

High voltage stack diode

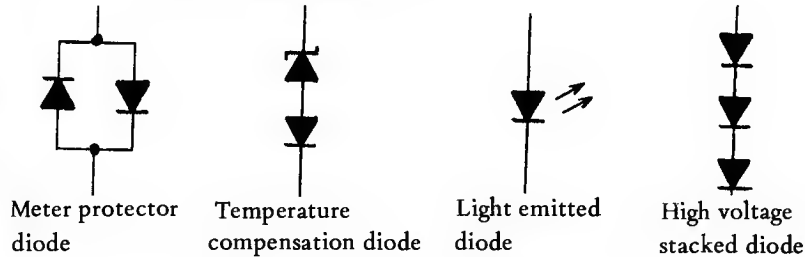


Fig. 5.2.2-1 Diodes not AUTO-tested

Those diodes which cannot be AUTO-tested by the LTC-906 are special diodes such as meter protection, temperature compensation, light emitting, high voltage stack diode, tunnel diode, constant current diode, etc. as partly shown in Fig. 5.2.2-1.

In the case of a bridge diode, each side of bridge can be individually tested.

In addition, the base-collector and base-emitter junctions of bipolar transistors, gate-drain and gate-source junctions of J-FETs and the PN junctions of other semiconductors can be AUTO-tested as diode.

5.3 DC PARAMETER test

The LTC-906 is capable of measuring basic DC parameter of bipolar transistor and diode and displaying measured values on the meter. Items of measurement are:

Forward base to emitter voltage of transistor	V_{BE}
Collector cutoff current with base open	I_{CEO}

Common emitter forward current transfer ratio h_{FE}

Forward/reverse voltage of diode V_D

Reverse leakage current LEAK

V_{BE} and V_D can be measured by using 0-3V range and used for determining good or bad of transistor or diode, the identification of Germanium type of Silicon type and determination of its polarity. I_{CEO} , LEAK and h_{FE} can be measured by using 3 ranges covering 1 to 10,000 and utilized for determining good/bad and identifying collector/emitter electrode.

Basic circuits for DC parameter measurement are shown in Fig. 5.3-1 and 5.3-2.

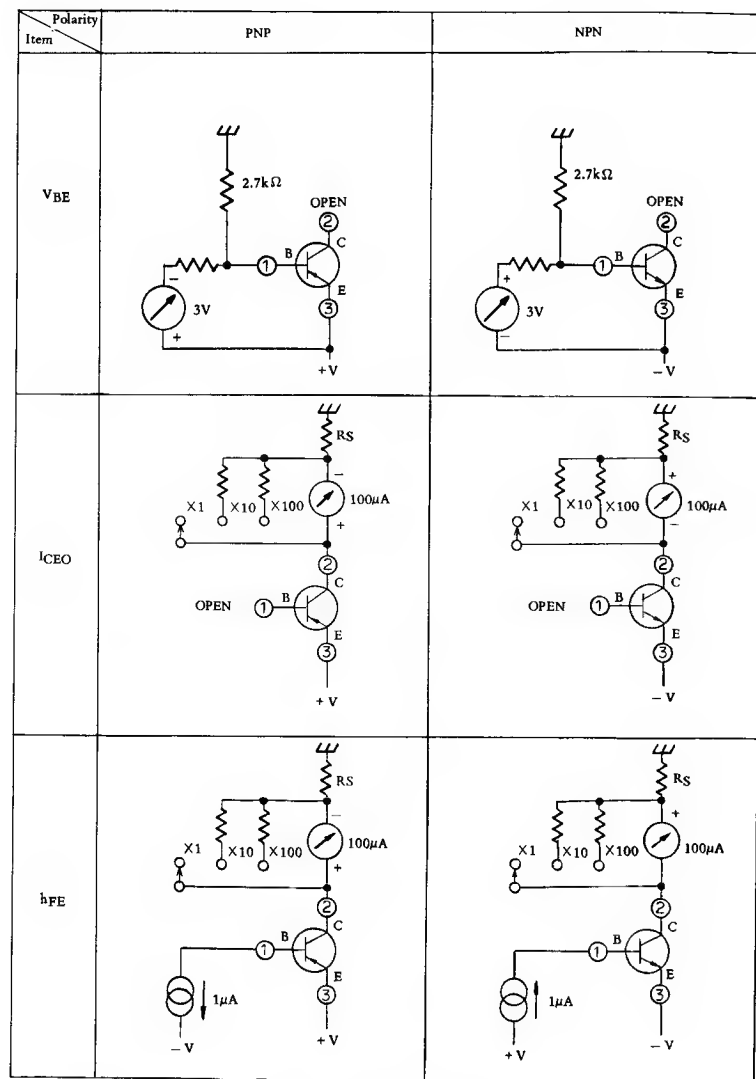


Fig. 5.3-1 Basic circuits for transistor DC parameter

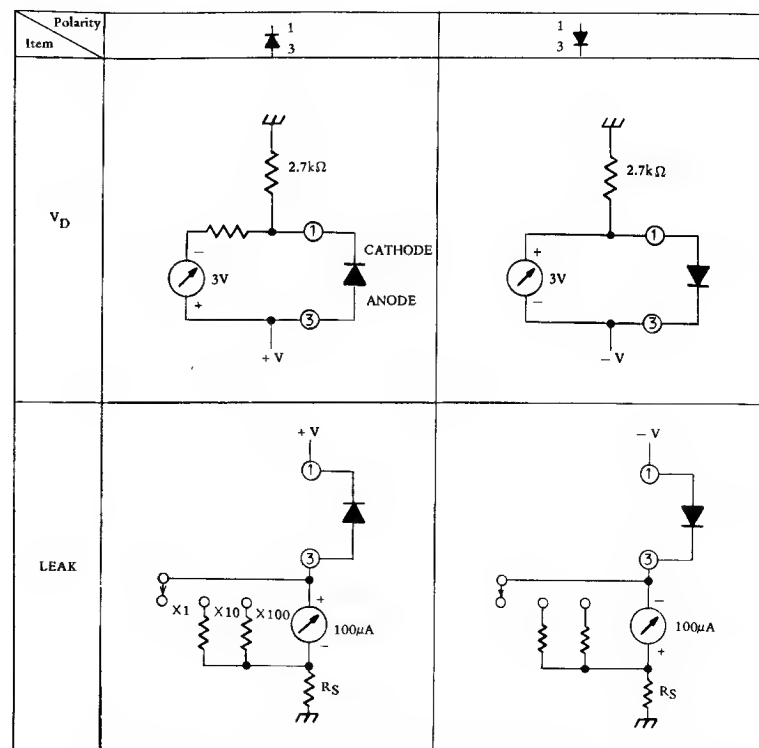


Fig. 5.3-2 Basic circuits for diode DC parameter

5.3.1 Transistor DC PARAMETER test

- (1) Set the AUTO/DC PARAMETER selector at DC PARAMETER.
- (2) Set the TRANSISTOR/DIODE selector at TRANSISTOR.
- (3) Turn the power switch on.
- (4) Set the meter selector at V_{BE} .
- (5) Insert a bipolar transistor to be measured directly into the test socket in the direction as designated, or connect it using a test lead. Connecting direction;

Socket contact	Electrode
1/blue	Base
2/green	Collector
3/yellow	Emitter

The type of electrodes of transistor must be known in advance. If they are unknown, they should be identified by transistor AUTO-test described in Par. 5.2.1.

In this case, if the collector cannot be distinguished from emitter, either one should be tentatively set as emitter. This can be made clear by h_{FE} measurement.

- (6) Set the polarity selector to the left, if the transistor is PNP, and to the right if it is NPN. If the polarity of transistor is unknown, it should be identified by the transistor AUTO-test described in Par. 5.2.1.
- (7) Read out the forward base to emitter voltage of the transistor from the V_{BE} scale of the meter. The V_{BE} scale indicates G_e and S_i . If the value of V_{BE} is about 0.25V, the transistor is of germanium and if it is around 0.7V, it is of silicon.

When the meter needle is out of scale, connecting direction of electrode is wrong, the polarity selector is set at reverse position, or the base of the transistor is of open circuit, etc.

- (8) Set the range selector at X100.
- (9) Set the meter selector at I_{CEO} and measure I_{CEO} of the transistor.

When the meter needle is moved outside the scale, its I_{CEO} is more than 10mA and it is poor in quality in many cases, or electrode connection or polarity selection is wrong. To prevent the depletion of battery, remove the transistor or turn the power switch off.

If the meter indicates between 10 and 100, the indicated value is multiplied by 100 to obtain I_{CEO} . For instance, if the meter indicates 32, $I_{CEO} = 32 \times 100 = 3,200 \mu A = 3.2mA$.

- (10) Set the range selector at X10 if the meter indication is less than 10. To obtain I_{CEO} , the indicated value is multiplied by 10. For instance, the meter indication is 45, $I_{CEO} = 45 \times 10 = 450 \mu A$.
- (11) Set the range selector at X1 if the meter indication is still less than 10. At this point, if the meter indication is 74, I_{CEO} is 74 μA .

I_{CEO} values of good quality transistors at normal temperature are as follows:

Si transistor of small signal	0 ~ several μA
Si transistor for power	0 ~ several μA
Ge transistor of small signal	Several ~ several hundreds μA
Ge transistor for power	Several tens ~ several thousands μA
Darlington Silicon transistor	Several ~ several hundreds μA

- (12) Set the range selector at X100
- (13) Set the meter selector at h_{FE} and measure forward current transfer ratio of the transistor, h_{FE} , and the indicated value on the h_{FE} scale is multiplied by 100 to obtain the value of h_{FE} .
- (14) Set the range selector at X10 if the meter indication is less than 10. To obtain h_{FE} , the meter indicated value is multiplied by 10.

- (15) Set the range selector at X1 if the meter indication is still less than 10. For instance, if the meter indication is 70, its $h_{FE} = 70$.

The LTC-906 is capable of measuring h_{FE} in 3 ranges up to 10,000, and these values cannot be regarded as the same as those listed in the data book due to different measuring conditions.

Measured values by this instrument are between several tens and several hundreds for ordinary small signal transistor and between several hundreds and several thousands for Darlington transistor.

In the case of a power transistor of which h_{FE} depends on collector current, its h_{FE} is shown with a fairly small value (less than 100) since measurement is done by a very small base current of $1 \mu A$.

- (16) Distinction of collector and emitter

In case the collector and emitter of a transistor are unknown, they can be distinguished by the difference in h_{FE} . The value of h_{FE} of a transistor when it is connected inverse direction with its emitter assumed as collector is decreased to 50 to 5% of that of h_{FE} to be obtained by normal connection.

When a transistor is unknown about its collector and emitter, its h_{FE} is measured with one of the two electrodes other than the base tentatively assumed as emitter and the other as collector. Again, h_{FE} is measured with those electrodes exchanged. One of these two cases in which is larger h_{FE} has been obtained shows the correct connection of the transistor.

- (17) Correction of h_{FE}

By the h_{FE} measuring method of LTC-906, an apparent h_{FE} is indicated larger than the true h_{FE} due to I_{CEO} especially in the case of a germanium transistor.

A true h_{FE} can be easily obtained by deducting I_{CEO} shown by the unit of μA from a measured value of h_{FE} . For instance, if a measured value of h_{FE} is 280 and I_{CEO} is $45 \mu A$, its true h_{FE} will be; $280 - 45 = 235$.

(Note) When base current is I_B and collector current is I_C ; the following relationship exists;

$$I_C = h_{FE} I_B + I_{CEO} \quad (a)$$

$$h_{FE} = \frac{I_C - I_{CEO}}{I_B} \quad (b)$$

In the LTC-906, a base current of $1 \mu A$ is caused to flow and collector current is measured by the unit of μA , therefore, the value of h_{FE} can be directly read out as the value of collector current from which the unit of μA is eliminated by ignoring I_{CEO} . If h_{FE} cannot be ignored, a value which is obtained by deducting I_{CEO} from I_C will be a true h_{FE} .

- (18) Calculation of I_{CBO}

The collector cutoff current with emitter open I_{CBO} , which is another DC parameter of transistor, can be obtained by the following computation:

$$I_{CBO} = \frac{I_{CEO}}{\text{True } h_{FE}} \quad (c)$$

For instance, I_{CBO} in the case of example (17) will be

$$\frac{45 \mu A}{235} = 0.19 \mu A$$

(19) To start a new measurement, return to Step (4)

5.3.2 Diode DC PARAMETER test

- (1) Set the AUTO/DC PARAMETER selector at DC PARAMETER'
- (2) Set the TRANSISTOR/DIODE selector at DIODE.
- (3) Turn the power switch on.
- (4) Set the meter selector at V_D .
- (5) Insert the two electrodes of a diode to be measured directly into contact 1 and 3 of the test socket, or connect them by using a test cable.
- (6) Set the polarity selector in the same direction as that of the connected diode if its polarity is known. If the polarity of diode is unknown, it should be round out by the diode test described in Par. 5.2.2, or it should be estimated from the value of forward/reverse V_D shown in (9).
- (7) Read out the forward voltage of diode V_D from the V_D scale of the meter. The meter needle is moved outside the scale when a diode is not connected, connection is in reverse direction or it is made as open circuit.
- (8) Set the polarity selector to the other side and read out the value of V_D again. This value is a reverse direction voltage of the diode. In the case of diodes of which leak current is

small such as silicon diode, etc., the meter needle is moved outside the scale in most cases when their reverse direction voltage is measured.

(9) Distinction of polarity

Since the forward voltage of a diode is generally larger than its reverse voltage, the polarity of a diode of which polarity is unknown can be estimated by comparing its forward voltage with its reverse voltage. In other words, the connection is which the value of V_D is smaller than the other is in forward, and at this time, it can be known from the direction of diode displayed by the polarity selector that the cathode of diode is connected to contact 1 or 3 of the test switch. For instance, if the value of V_D is smaller when the polarity selector is set at the left position, the cathode electrode is connected to contact 1 side of the test switch.

(10) Identification of type of diode

The type of diode can be presumed by the amount of forward voltage or reverse voltage as shown in Table 5.3.3-1. The V_D scale of the meter indicates the representative ranges of forward voltage to serve as guideline to identify germanium and silicon diode.

(11) Set the polarity selector at the same direction as that of the connected diode.

(12) Set the range selector at X100.

(13) Set the meter selector at LEAK and measure reverse leak current of diode on the LEAK scale of the meter.

When the meter needle is moved outside the scale,

- a. Setting of the polarity selector is reverse.
- b. Leak current of diode is larger than 10mA.

c. Diode is short-circuit

d. Diode is of special type such as meter protection, tunnel, trigger, etc.

In such a case, immediately stop measurement to protect the diode from damage and prevent the depletion of battery and remove the diode or turn the power switch off. If the meter indicates between 10 and 100 on the LEAK scale, the indicated value is multiplied by 100 to obtain a leak current, for instance, if the meter indication is 35, a leak current = $35 \times 100 = 3,500 \mu A = 3.5mA$.

(14) Set the range selector at X10 if the meter indication is less than 10, and multiply the meter indication by 10. For instance, if the meter indication is 85, leak current will be $85 \times 10 = 850 \mu A$.

(15) Set the range selector at X1 if the meter indication is still less than 10, and read out the meter indication.

For instance, if the meter needle indicates 15 on the LEAK scale, its leak current is $15 \mu A$.

In the case of a silicon diode, its leak current is very small at normal temperature, and the meter needle hardly moves in many cases.

In the case of a germanium diode, it is between several and several hundreds μA .

(16) To start a new measurement, return to Step (4).

(Note) At the time of diode DC parameter test, the left hand side position of the meter selector does not have any function.

Diode	Forward voltage (V)	Reverse voltage (V)	Leak current (μA)
Germanium small signal	0.1 ~ 0.5	1 ~ full scale	Several ~ Several 100
Germanium power	0.2 ~ 0.7	1 ~ full scale	Several 10 ~ Several 1000
Silicon small signal	0.3 ~ 1	Full scale	0 ~ Several 10
Silicon power	0.5 ~ 1.5	Full scale	0 ~ Several 100
Light emitting	1.5 ~ 3	Full scale	0 ~ Several 10
Meter protection	0.2 ~ 0.7	same as forward voltage	
Zener	0.3 ~ 1	Full scale	0 ~ Several 100
Temperature compensation Zener	Full scale	Full scale	0 ~ Several 10

- (Caution)
1. The light emitting diode generates weak light when its forward voltage is measured. In measuring a leak current, the light emitting diode emits strong light by a large forward current which is caused to flow by setting the polarity switch in reverse.
 2. The forward voltage of a temperature compensation Zener diode becomes full scale as it is a temperature compensation diode.
 3. In the case of a bridge diode, each side of the bridge can be individually measured.
 4. DC parameter can be measured by assuming PN junction of base-collector and base-emitter of bipolar transistor and gate-drain and gate-source of junction type FET as diode. In this case, for measuring a leak current, if a large forward current is caused to flow by mistake, such a current may damage junctions.

